LOCATION PATTERNS OF INNOVATION SECTORS AT METROPOLITAN SCALE

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This paper[1] analyzes the location patterns at a metropolitan scale of the most intensive sectors in innovative activities and, in particular, those linked to ICT (information and communication technologies). The innovative capacity of these sectors is largely explained by the external environment to the company. Because of that they tend to cluster in the central nucleus of the metropolitan areas where they can benefit from the external knowledge generated as a result of this concentration. This paper carries out a location analysis of the intra-sector scope and also shows what inter-sector links are found between innovative sectors in terms of their location preferences and the physical proximity between companies from different sectors.

1. Motivation

The activities linked to ICT (Information and Communication Technologies) have experienced a strong expansion in Catalonia in recent years, especially in the metropolitan area of Barcelona where companies connected to these sectors find an economic and financial environment more convenient for their location requirements. In addition to this clear preference for the metropolitan environment of Barcelona, ICT activities show a tendency towards agglomeration much more intensely than other sectors, as a result of the close interdependencies between companies in related sectors.

ICT activities have traditionally been at the epicentre of growth strategies carried out by cities in the most developed countries due to the numerous positive externalities linked to them. In this regard, ICT activities generate highly qualified employment in technology-intensive activities. They collaborate to establish a whole network of companies that provide specialized services for companies in the sector (also in technology-intensive activities), give prestige to the territories where they are located in and do not cause negative externalities in environmental terms or linked to land uses.

In Catalonia, the ICT sector is one of sectors with a greater capacity for growth and generation of employment. Thus, in 2015 there were more than 84,000 direct jobs in this sector (with average salaries higher than 30,000 Euros per year). The sector in general contributed more than 15,000 million Euros to GDP, which represents around 25% of the GDP of the ICT sector of the State (Instituto Nacional de Estatística, 2015). Raising capital is another indicator of business dynamism. In this sense, in the same year it obtained more than 324 million Euros of investment in technological start-ups, which represents more than 60% of the total investment in start-ups in the Spanish State (Instituto

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Nacional de Estadística, 2015). Thus, due to the importance of this sector several public policies regarding the deployment of electronic communication infrastructures have been made to guarantee the competitiveness of the involved companies. The agglomeration of Barcelona (and the city in particular) stands out for using ICTs in very different areas of daily life due to the high availability of ICT infrastructures (such as the fibre optic network or the municipal Wi-Fi network). It also stands out for the ability to attract talent in these sectors thanks to a high quality of life, and the existence of leading companies that not only attract others but also stimulate the creation of start-ups around them (the cases of T-Systems, Yahoo, Microsoft or Hewlett Packard, among others). Additionally, there are support networks for research and technology transfer that allow improving the competitive capacity of companies. In addition, the dynamism of the sector is explained by milestones such as the presence of the Mobile World Conference in Barcelona in 2012, an event that reinforced Barcelona as the capital of the mobile telecommunications subsector and collaborated to attract new companies in the sector.

This paper aims to analyze the location dynamics of companies within the ICT sector in the metropolitan agglomeration of Barcelona from the role played by the ICT activities in the processes of economic growth experienced by the main European metropolitan agglomerations. Thus, the interest of this paper goes beyond knowing where these companies are located within the metropolitan area and focuses on analyzing in detail what dynamics of agglomeration occur between companies belonging to ICT activities. This is a key point for their competitiveness, given that the large empirical evidence available suggests the existence of close relationships of interdependence between the various ICT sectors, relationships that also have a translation in terms of physical proximity.

2. Data and methodology used

The territorial scope under analysis is made up of the Metropolitan Area of Barcelona (AMB) with the addition of a set of close by municipalities that take part in the metropolitan life and that have strong interactions in terms of labour markets and of forced daily commute. Specifically, the paper uses the first three zones of the geographical area of the Integrated Tariff System of the Barcelona area, which includes a total of 102 municipalities.[2]

2 Out of these municipalities, 17 belong to zone 1, 43 belong to zone 2 and 42 belong to zone 3.

2.1 Data

The data related to companies belonging to the ICT sectors (Information and Communication Technologies) come from the Sistema de Análisis de Balances Ibéricos (SABI) database compiled by INFORMA D & B and Bureau Van Dijk, with information from the Mercantile Registry. This database contains exhaustive information at company level and has an increasing coverage of the business sector.

Table 1 shows the list of sectors under analyse for the years 2006, 2010 and 2015. The use of the aforementioned years allows us to check for the spatial distribution of ICT companies for the previous (2006), later (2015) and central (2011) periods of the crisis, in order to avoid any bias caused by it.

2.2 Methodology: the M functions

This paper uses the M function to evaluate the concentration and agglomeration[3] of ICTs in the extended metropolitan area of Barcelona. This function, introduced by Marcon and Puech (2009, 2003), is a relative function based on distance that allows comparing the proportion of companies of interest in a specific area in relation to the proportion of companies of interest in the area of reference as a whole. The M function can be interpreted as the equivalent to the localization coefficient from a

3 In this paper, the term concentration refers to a group of companies from the same sector, whilst the term agglomeration is used for a group of companies from different sectors.

Table 1. ICT activity sectors

Activity	Acronym	CNAE 2009 (3 DIG)
Software editing	EPI	582
Cable Telecommunications	TC	611
Wireless telecommunications	TSF	612
Satellite telecommunications	TS	613
Other telecommunications activities	AT	619
IT Services	STI	620
Data processing, hosting and related activities; Web portals	PHW	631
Total activities	TIC	-
Rest of economic activity	RAE	-

Source: authors' elaboration based on data from SABI

distance-based perspective.[4] The results obtained allow us to identify whether there is significant concentration or agglomeration (dispersion), if the proportion of companies of interest in the area of reference is higher (lower) than that of the whole area of study.

Among the advantages of using the M function, we can highlight the fact that it allows us to control for the global concentration patterns of each sector, as well as industrial concentration, which remains unchanged between different geographical scales and which allows us to verify the statistical significance of the results (Lang et al., 2015; Marcon and Puech, 2009). In addition, this function stands out as it takes into account the existence of heterogeneous geographical spaces and facilitates the interpretation and comparability of the results in a direct and simple way.

In this paper, the M function is calculated for each 1,000 meters in a radius between 0 and 60 km thanks to the use of micro-data corresponding to the companies located in the extended metropolitan area. The dbmss package (Marcon et al., 2015) available in the free R statistical software has been used for the estimation.

Function M: concentration at intra-industry scale

The function M used to calculate the spatial concentration at intra-industry scale in a circle of radius r for a sector S is defined as follows:

$$M(r,S)=\sum_{i=1}^{N_S}\frac{e_{iSr}}{e_{ir}}\Big/\sum_{i=1}^{N_S}\frac{E_S-e_i}{E-e_i}$$

where i = 1, 2, ..., n is a company index, e defines the number of companies in the reference area and E is the total number of companies in the whole area. Its estimation is organized in different phases. At the beginning, all the companies belonging to S sector are identified in the area under analysis. In this paper, an S sector refers to companies in the ICT sectors. Around each of these companies, a circle of radius r is drawn (for example, 1 km). Within this distance, the number of companies that are part of the sector S ($eiSr$) are counted. Next, the sum of these companies on i is defined as the proportion of the number of companies in all sectors of economic activity within the same circle. Finally, this quotient is divided by that of sector S in the totality of the economic activity of the whole extended metropolitan area.

The reference value to be able to interpret the M function is 1, so that values of M equal to 1 indicate that, for any considered radius, proportionally there is the same number of companies from sector S than from the whole area analyzed. This result indicates that the location of companies in sector S is random. Values of M greater than 1 indicate that there are proportionally more companies close to companies in sector S in a radius r than in the area as a whole, that is, that there is a geographical concentration relative to that of sector S at a distance r. Finally, values of M lower than 1 indicate that there are relatively fewer companies in sector S within a radius r than in the whole area, in other words, that sector S is relatively dispersed at distance r.

The statistical significance of the M function is calculated by the construction of confidence intervals for the null hypothesis based on the independence of the location of the companies (in this case, that the companies that are part of the S sector are located following the same pattern as the rest).

The use of the Monte Carlo method allows defining the confidence intervals in the following way. First, a large number of simulations (1,000) are generated. Secondly, a confidence level of 5% is fixed, so that 95% of the confidence interval of the M for each value of r is limited by the remaining 5% of the randomly generated values. Thus, there is significant relative concentration (dispersion) in the analyzed sector if the corresponding values of M are higher (lower) than 1 and fall outside the bands of the confidence intervals.

Function *M*: agglomeration at inter-industry scale

The inter-industry version of the M function analyzes the existence of agglomeration. Specifically, the agglomeration functions M for sectors $S1$ and $S2$ are defined similarly to the definition of M (r, S) but, in this case, the denominator slightly varies:

4 The location quotient (LQ) is defined as LQ= (Lij,/ Lj) / (Li / L), where Lij is the number of companies of the industry j in the region i; Lj is the total number of companies in the industry j; Li is the total number of companies in region i, and L is the total number of companies in the area (for instance, region or country). LQ values over 1 indicate that the concentration of the industry j in the region i is higher than the average of all the territory under analysis, therefore this region is specialized in the specific industry.

> *Among other factors, the interest of the ICT sector lays in its dynamic behaviour in a context of crisis and slowing down of economic activity*

$$M_{S_1S_2}(r)=\sum_{i=1}^{NS_1}\frac{e_{iS_2}r}{e_{ir}}\Big/\sum_{i=1}^{NS_1}\frac{E_{S_2}}{E\text{-}e_i}$$

$$M_{S_2S_1}(r)=\sum_{i=1}^{NS_2}\frac{e_{iS_1}r}{e_{ir}}\Big/\sum_{i=1}^{NS_2}\frac{E_{S_1}}{E\text{-}e_i}$$

Thus, M_{S1S2} (M_{S2S1}) illustrates the spatial structure of companies in sector $S2$ ($S1$) that are located around the sector $S1$ ($S2$). The value indicates whether the relative density of the companies $S2$ ($S1$) located around the companies in the sector $S1$ ($S2$) is higher or lower than the density observed in the whole area. The statistical significance of the inter-industrial function of M is evaluated following the same methodology as in the case of the intra-industrial function presented above, although the construction of confidence intervals is slightly more complicated. Significant values of M (r, $S1$, $S2$) can be explained either by the possible interaction between sectors or by specific patterns for each of the sectors $S1$ or $S2$. Thus, the null hypothesis should control for both cases. In this way, the null hypothesis of all the points for $MS1S2$ (r) is generated by keeping the points of $S1$ unchanged and redistributing all the rest of the points in all other possible locations. The same process is applied for $S2$. In this sense, there will be significant agglomeration as long as both values are significantly different from their respective null hypotheses (Marcon and Puech, 2009).

3. Results

3.1. Descriptive analysis

Among other factors, the interest of the ICT sector lays in its dynamic behaviour in a context of crisis and slowing down of economic activity. Thus, a look at table 2 shows how in the period from 2006 to 2015 the number of ICT companies in the area under study remained slightly high, while companies belonging to the rest of the sectors experienced a decline by 3.3%. In a context of crisis and post-crisis, the results of ICT show the resilience of the sector and the goodness of the sector specialization strategy in these activities.

In addition, these are sectors with certain stability (at least during the period analyzed). In terms of the inflows and outflows, table 3 shows there is a high persistence in terms of the companies that continue in the market throughout the period, given that the rotation (inflows plus outflows) only represents 8.8% of the stock in 2010 and 6.6% in 2015.

To have an initial overview of the distribution of ICT companies in the metropolitan area of Barcelona, figure 1 shows a heatmap indicating the density of ICT companies. As could be expected, almost all ICT companies are located in urban areas and, among them, the cases of Barcelona and Sant Cugat del Vallès stand out, a pattern that is stable between 2006 and 2015.

Regarding the location of each of the ICT sectors, Figure 2 shows the existence of subsectors such as editing software (EPI for its Catalan acronym), cable telecommunications (TC for its Catalan acronym), wireless telecommunications (TSF for its Catalan acronym) and satellite telecommunications (TS for its Catalan acronym) with a low number of companies and a location, in general, in the central areas (a pattern that in the case of

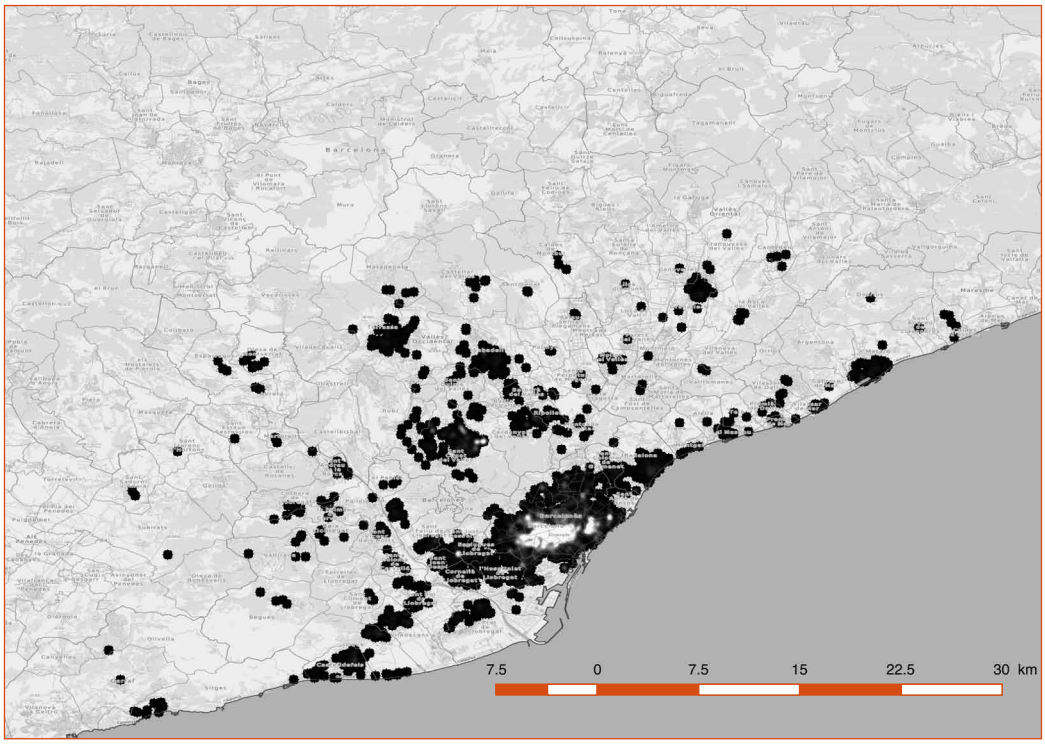
Table 2. Temporary evolution of ICT Companies (2006, 2010 i 2015)

Sectors TIC	2006	2010	2015
EPI	59	63	61
TC	37	40	37
TSF	15	13	13
TS	6	6	6
AT	387	392	382
STI	3.312	3.365	3.358
PHW	196	197	201
Total TIC	4.012	4.076	4.058
	2,55%	2,60%	2,67%
RAE	153.464	152.918	148.159
	97,45%	97,40%	97,33%
Total	157.476	156.994	152.217
	100,00%	100,00%	100,00%

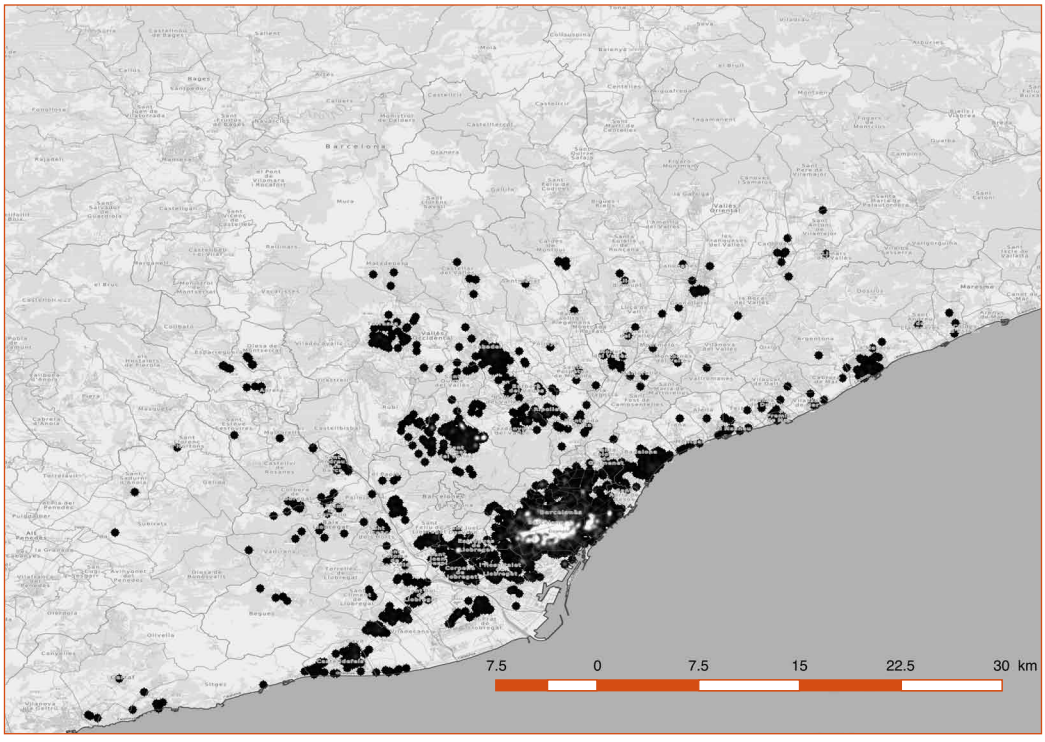
EPI (software editing), TC (cable telecommunications), TSF (wireless telecommunications), TS (Satellite telecommunications), AT (other telecommunications activities), STI (IT services), PHW (Data processing, hosting and related activities; Web portals) and RAE (Rest of economic activity).
Source: authors' elaboration based on data from SABI

Graph 1. Spatial distribution of ICT companies (2006 i 2015)

2015

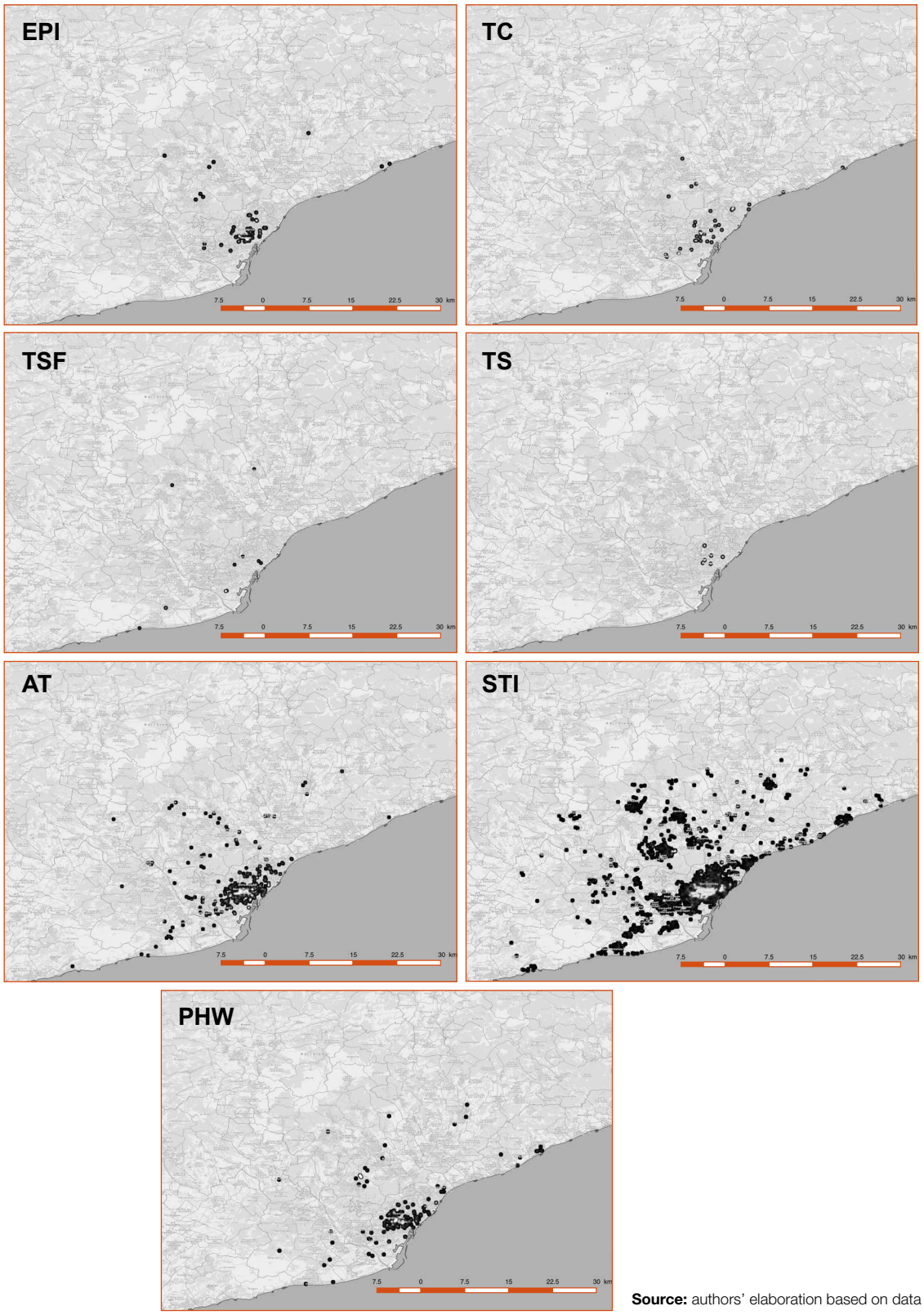


2006



Source: authors' elaboration based on data from SABI

Graph 2. Spatial distribution of ICT subsectors companies (2015)



Source: authors' elaboration based on data from SABI

Table 3. ICT companies evolution (2006, 2010 i 2015)

	2006	2010	2015
Total TIC	3.923	4.077	4.059
Inflow	-	256	124
Outflows	-	102	142
Remain	-	3.821	3.935

Source: authors' elaboration based on data from SABI

TC, TSF and TS is partly explained by the high level of specialization with a very limited demand and with relatively high operating costs); while the subsectors information technology services (STI for its Catalan acronym), other telecommunications activities (AT for its Catalan acronym) and data processing, hosting and related activities; Web portals (PHW for its Catalan acronym) have a larger number of companies and are more widespread throughout the territory, mainly due to the fact that they show an industrial structure basically of SMEs.

Among the factors that favour the spatial concentration of the ICT sectors around Barcelona, we can highlight the accessibility to the transport infrastructure, the high possibilities of interaction between companies in the same sector and related sectors, the telecommunications network, the availability of highly qualified workers and the positive effect of the Barcelona brand (Barcelona City Council, 2013, 2012, 2007). In this sense, it refers to location appeal with a high persistence, which generates a path dependence in the spatial distribution of companies.

3.2 Intra-industry concentration

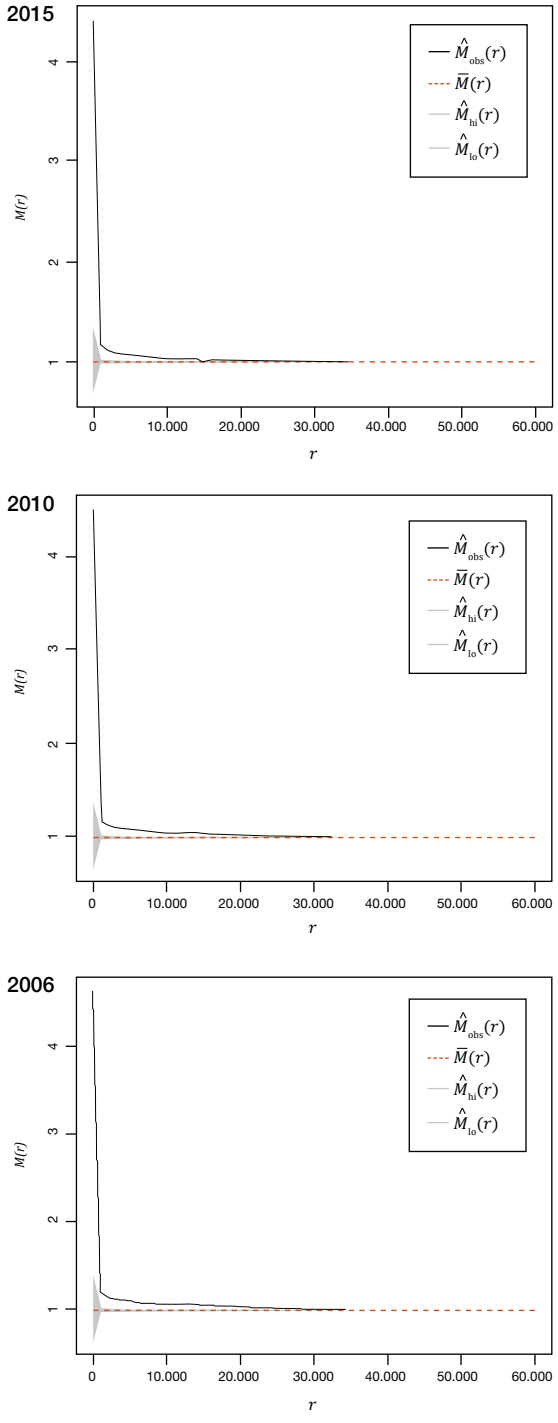
Regarding the analysis of geographic concentration processes, Figure 3 shows the concentration of all the ICT sectors for the years 2006, 2010 and 2015 from the use of the M function. Thus, as mentioned in Section 2 of this article, the M function allows measuring the intensity of concentration (dispersion) of economic activity in a specific territory. As for the companies in the ICT sectors, the results indicate a clear persistence in the patterns of concentration of these sectors in the extended metropolitan area of Barcelona. This way, a high concentration of ICT activities can be seen in a radius of between 1 and 2 km from which there is a rapid decrease, so that the concentration disappears around 20 km. Specifically, in 2015 (with a value of the M function of 4.40 up to the first kilometre), the concentration of ICT sectors was 4.40 times higher than the concentration of the rest of the sectors in this area. This result is robust, since it has remained fairly stable since 2006. In fact, for 2006 and 2010 the values of the M function were 4.62 and 4.98, respectively, being also significant up to around the 20 km. Therefore, these results show a clear persistence in the concentration intensity of the ICT sectors, for which the impact of the economic crisis has been lower than for the rest of the economic activities (CTecno, 2017; ASEITEC, 2014; Propris, 2013). These dynamics could be explained by factors such as the previous specialization in ICT activities, in general, and by the importance of the Barcelona's brand, in particular.

Although the previous results show some general patterns for all ICT sectors, it is necessary to see to what extent there are specificities at subsector level. In this sense, table 4 shows how the concentration patterns vary between sectors. Thus, a clear intensity of concentration is observed for most ICT sectors (with the exception of EPI and TS) within the first section of the function (0-7 km). From the second section of the function (7-14 km) the concentration loses intensity and ceases to be significant in most cases. These results confirm previous expectations about the greater incentives of ICT companies to concentrate in and around Barcelona (Coll-Martínez et al., 2019, Arauzo-Carod et al., 2017) in order to benefit from aspects such as the degree of tacit knowledge in this area that is so important in this type of activities. As several authors point out, concentration helps the transfer of tacit knowledge through direct and daily interaction between several agents (Storper and Venables, 2003). As these are highly innovative sectors, concentrating on large cities and the corresponding metropolitan area helps interaction among skilled workers as well as the transmission of innovative ideas (Henderson, 2003; Glaeser et al., 1992).

3.3 Inter-industry agglomeration

In addition to the processes of agglomeration analyzed previously, it should be noted that certain sectors tend to agglomerate with others, either because they both need the same type of environment or because there is some type of interdependence (symmetrical or not) according to which positive effects on companies in the sector are generated (arising from the geographical proximity between them). In this sense, the analysis of the location patterns of the ICT sub-sectors allows for the empirical identification of cases of significant agglomeration. To show these effects, among the various combinations of ICT subsectors, two pairs of subsectors have been selected that present significant agglomeration patterns. The first pair of subsectors

Graph 3. Concentration of the ICT sectors (2015, 2010, 2006)



Note: vertical axis (value M); horizontal axis (metres). A thousand simulations have been performed for each function.
Source: authors' elaboration

is made up of the software editing sector (EPI) and the rest of the ICT subsectors, while the second pair is formed by the subsector of data processing, hosting and related activities (PHW) and the rest of ICT subsectors. The results for the first pair (figure 4) show a clear tendency of agglomeration between companies in this subsector and the rest of ICT activities, which could be indicating some type of interdependence. More specifically, the results for the Barcelona area in 2015 indicate that ICT companies (not including the EPI sector) are located around the EPI subsector with a value of the M function of 3.41 (that is, more than three times of which would be expected in a scenario of random distribution of the companies), while those of the subsector EPI do it around those of the rest of the ICT subsectors with a value of the M function of 4.04 at very short distances.

The results for the PHW sector and the rest of the ICT subsectors (figure 5) are quite similar, although they show a lower intensity in the agglomeration. In this case, the results indicate that the ICT companies (not including the PHW sector) are located around those of the PHW subsector with a value of the M function of 2.88, and those of the EPI subsector do it around those of the rest of ICT subsectors with a value of 3.11 at very short distances too.

Finally, the results on agglomeration between the different ICT sub-sectors and between each of these and all of ICT activities

Table 4. Concentration of the ICT subsector in the extended metropolitan area of Barcelona using the M function. 2015

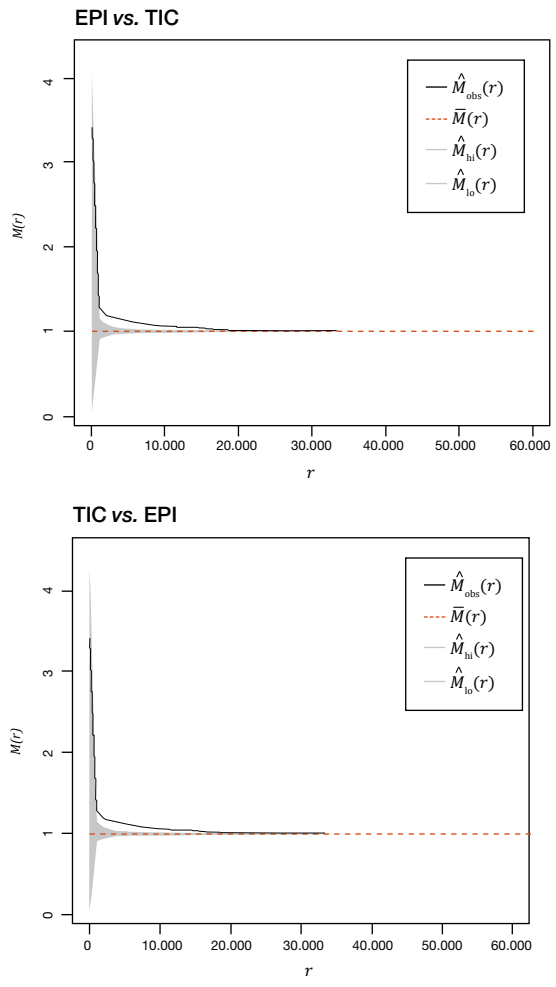
	0-7 km	7-14 km	14-60 km
EPI	*NS*	*NS*	*NS*
TC	*C*	*NS*	*NS*
TSF	*C*	*NS*	*NS*
TS	*NS*	*NS*	*NS*
AT	*C*	*NS*	*NS*
STI	*C*	*CL*	*NS*
PHW	*C*	*NS*	*NS*
TIC	*C*	*CL*	*NS*

Note: concentration (C); light concentration (CL); non-significant (NS); dispersion (D). A thousand simulations have been performed for each calculation. This same analysis has been performed for 2005 and 2010, and in general terms the same results have been obtained.
Source: authors' elaboration

are summarized in Table 5.[5] Although most subsectors are highly agglomerated with all the ICT activities (with the exception of the TSF subsector), there are important differences at the subsector level on inter-sector interdependencies in terms of geographical proximity. Thus, the agglomeration between companies in the EPI subsectors with information technology and information service (STI) activities and between the PHW and STI subsectors stand out. The agglomeration between these subsectors in the case of the area of Barcelona can be largely explained by the fact that the companies that operate in these subsectors are located mainly in the 22 @ district, an area that has attracted companies of high technological intensity from a wide range of activity sectors (Viladecans-Marsal and Arauzo-Carod, 2012, Barber and Pareja-Eastaway, 2010). In this case, the agglomeration between these subsectors can be explained both by the interconnection of their production networks and by the effects of a cluster policy aimed at providing services potentially driving business productivity (such as spaces of more appropriate dimensions, co-working centres, accessibility to university centres for training human capital or public help, among others).

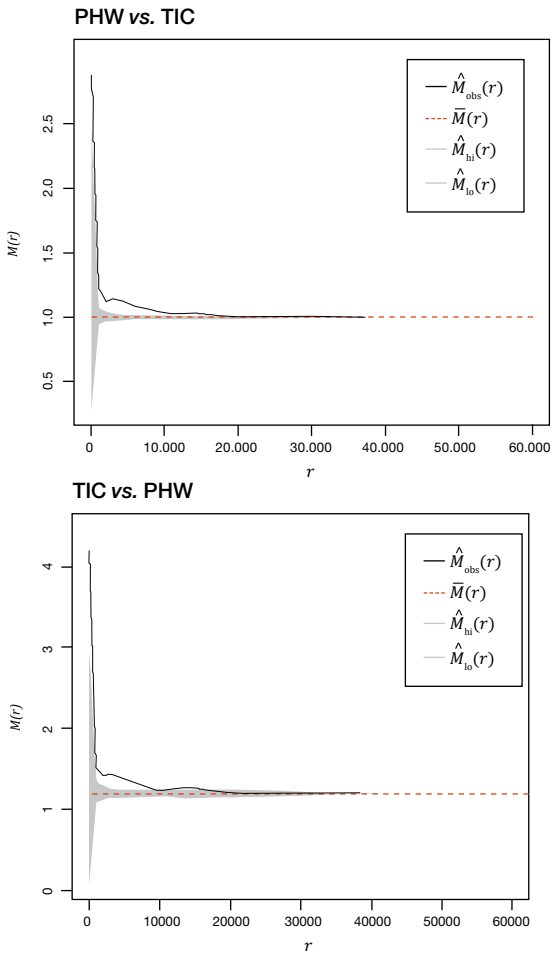
5 The values of the diagonal of the matrix are equivalent to the intra-sector concentration for the first section of table 4, as they analyze the concentration of companies of a sector around the same sector.

Graph 4. Agglomeration between software editing (EPI) and ICT



Note: vertical axis (value M); horizontal axis (metres).
A thousand simulations have been performed for each function.
Source: authors' elaboration

Graph 5. Agglomeration between Data processing, hosting and related activities; Web portals (PHW) and ICT



Note: vertical axis (value *M*); horizontal axis (metres).
A thousand simulations have been performed for each function.
Source: authors' elaboration

It is worth saying that the preceding examples of agglomeration between these subsectors and some of them with the rest of the ICT subsector support the idea that ICT activities have clear incentives to be located in the same places to have more possibilities of interaction among different economic agents. These dynamics have been identified for the same sectors in other European urban areas as Milan or Lyon (Espa et al., 2013; Moriset, 2003), where the location dynamics of highly innovative sectors such as ICTs show remarkable similarities.

4. Conclusions

This paper has focused on the Barcelona area with the aim of analyzing the concentration and agglomeration processes of companies in highly innovative sectors such as ICT (Information and Communication Technologies). These sectors tend to show location patterns highly concentrated in the central areas of the large urban areas and their immediate peripheries, due to the advantages that in terms of agglomeration economies emerge in these places. In addition to this preference for centrality and bearing in mind that knowledge spill-overs between companies are much more intense in short distances (Rosenthal and Strange, 2008), ICT companies have clear incentives to be located close to each other.

This study makes use of the relative distance-based M function and micro-geographic data from the Mercantile Registry for the years 2006, 2010 and 2015. Specifically, the results for this function show some patterns of concentration and agglomeration of the ICT subsectors, although with notable differences for each of them, which shows how the preference for centrality and proximity to other ICT activities are modulated according to the specific characteristics of each subsector.

All in all, these results suggest that Barcelona area is an obvious magnet for these highly intensive activities in technology and knowledge, which explains why companies in these sectors are willing to bear the extra costs generated by centrality in exchange for reasonable expectations to assume efficiency improvements that are surely unreachable in other peripheral locations. Therefore, the public administrations involved should continue to support these activities to the effect that the city of Barcelona, its metropolitan area and the municipalities adjacent to it can continue to benefit from the presence of these companies and, this way, continue to stimulate the whole of the Catalan economic activity.

Table 5. Agglomeration between ICT subsectors in the extended area of Barcelona using the M function. 2015

	EPI	TC	TSF	TS	AT	STI	PHW	TIC
EPI	*	-	-	-	-	-	-	-
TC	*NS*	*	-	-	-	-	-	-
TSF	*NS*	*NS*	*	-	-	-	-	-
TS	*NS*	*NS*	*NS*	*	-	-	-	-
AT	*AL*	*NS*	*NS*	*NS*	*	-	-	-
STI	*A*	*NS*	*D*	*NS*	*A*	*	-	-
PHW	*AL*	*NS*	*NS*	*NS*	*AL*	*A*	*	-
TIC	*A*	*AL*	*D*	*AL*	*A*	*A*	*A*	*

Note: agglomeration (A); light agglomeration (AL); non-significant (NS); dispersion (D).(*) They refer to the level of concentration (see table 4). A thousand simulations have been performed for each function. This same analysis has been performed for 2005 and 2010, and in general terms the same results have been obtained.
Source: authors' elaboration

References

Arauzo-Carod, J. M.; Coll-Martínez, E.; Méndez-Ortega, C. (2017). "Aglomeración de sectores intensivos en conocimiento: una aproximación intraurbana". *Papeles de Economía Española* (num. 153, p. 110-126).

ASEITEC (2014). "El sector TIC supera els pitjors anys de la crisi tot i que no recupera facturació". Available at *https://www.aseitec.org/ conclusions-barometre-tic-2014/*.

Ajuntament de Barcelona (2007). "TIC, tecnologies de la información i la comunicació a Barcelona i Catalunya". Available at *http:// www.22barcelona.com/documentacio/tic_cat.pdf*.

Ajuntament de Barcelona (2012). "El sector TIC a Barcelona". Available at *http://barcelonacatalonia.cat/b/wp-content/uploads/2012/12/castellanoTIC-2303.pdf*.

Ajuntament de Barcelona (2013). "Barcelona metròpoli creativa". Available at *http://ajuntament.barcelona.cat/barcelonaeconomia/es/ estudis-i-publicacions*.

Barber, A.; Pareja-Eastaway, M. (2010). "Leadership challenges in the inner city: Planning for sustainable regeneration in Birmingham and Barcelona". *Policy Studies* (num. 31, p. 393-411).

CTecno (2017). *Baròmetre del sector tecnològic a Catalunya 2017*. Available at *http://www.ctecno.cat/wp-content/uploads/2017/07/ CAT_DEF.pdf.*

Espa, G.; Arbia, G.; Giuliani, D. (2013). "Conditional versus unconditional industrial agglomeration: Disentangling spatial dependence and spatial heterogeneity in the analysis of ICT firms' distribution in Milan". *Journal of Geographic Systems* (num. 15, p. 31-50).

Coll-Martínez, E.; Moreno-Monroy, A.; Arauzo-Carod, J. M. (2019). "Agglomeration of creative industries: An intra-metropolitan analysis for Barcelona". *Papers in Regional Science*, (vol. 98, num. 1, p. 409-432).

De Propris, L. (2013). "How are creative industries weathering the crisis?".*Cambridge Journal of Regions, Economy and Society* (num. 6, p. 23-35).

Glaeser, E.; Kallal, H.; Scheinkman, J.; Schleifer, A. (1992). "Growth in cities". *Journal of Political Economics* (vol. 6, num. 100, p. 1126-1152).

Henderson, J. V. (2003). "Marshall's scale economies". *Journal of Urban Economics* (vol. 1, núm. 53, p. 1-28).

Institut d'Estadística de Catalunya (2015). *Empreses i ocupació del sector TIC. Catalunya. 2015*. Available at *https://www.idescat.cat/pub/?id=etic&n=2*.

Instituto Nacional de Estadística (2015). *Indicadores del sector de tecnologías de la información y las comunicaciones (TIC)*. Available at http://www.ine.es/dyngs/INEbase/es/operacionhtm?c=Estadistica_C&cid=1254736176742&menu=ultiDatos&idp=1254735576692.

Marcon, E.; Traissac, S.; Puech, F.; Lang, G. (2015). "Tools to Characterize Point Patterns: dbmss for R". *Journal of Statistical Software* (vol. 3, num. 67, p. 1-15).

Marcon, E.; Puech, F. (2009). "Measures of the geographic concentration of industries: improving distance-based methods". *Journal of Economic Geography* (vol. 5, num. 10, p. 745-762).

Marcon, E.; Puech, F. (2003). "Evaluating the geographic concentration of industries using distance-based methods". *Journal of Economic Geography* (vol. 4, num. 3, p. 409-428).

Moriset, B. (2003). "The new economy in the city: Emergence and location factors of internet-based companies in the metropolitan area of Lyon, France". *Urban Studies* (num. 40, p. 2165-2186).

Rosenthal, S. S.; Strange, W. C. (2008). "The attenuation of human capital spillovers". *Journal of Urban Economics* (num. 64, p. 373-389).

Storper, M.; Venables, A. J, (2003). "Buzz: face-to-face contact and the urban economy". *Journal of Economic Geography* (vol. 4, num. 4, p. 351–370).

Viladecans-Marsal, E.; Arauzo-Carod, J. M. (2012). "Can a knowledge-based cluster be created? The case of the Barcelona *22@* district". *Papers in Regional Science* (num. 91, p. 377-400).